

MAMMOTHS *and* MASTODONS

Ice Age Elephants of New York



by judith drumm



educational leaflet *** 13

The University of the State of New York
The State Education Department
STATE MUSEUM AND SCIENCE SERVICE
Albany, 1963

MASTODONS AND MAMMOTHS ICE AGE ELEPHANTS OF NEW YORK

By

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Museum Instructor



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PREFACE

At one end of Paleontology Hall in the New York State Museum are several exhibits on mammoths and mastodons, including two mounted mastodon skeletons and a life-size mastodon restoration. Imposing as this display is, most visitors remember it only as "those bones" or "that shaggy elephant." (Regrettably, a few refer to "the dinosaur.") This leaflet is written for one group of visitors, teachers, to help them teach paleontology and explain the exhibit to their pupils. In it, the author has described mammoths and mastodons, their anatomy, habitat, and history, with emphasis on specimens found in the State. Data from early New York mastodon discoveries contributed significantly to the development of vertebrate paleontology. In addition, a number of these specimens were connected with famous people. Although fragmentary New York mammoth remains are more tantalizing than enlightening, they are proof that the animal lived in the area during postglacial times. More details of mastodon habitat have been determined by the use of modern scientific techniques.

Dr. Donald Fisher, Dr. Edgar Reilly, Jr., and Dr. John Broughton, of the New York State Museum and Science Service, have provided invaluable help and information. Louis Koster supplied material on the exhibits. The cover and illustrations were done by Robin Rothman; the map and time scale, by Gwyneth Gillette. The author is also grateful to all those who read and criticized the manuscript. Part of the funds for this project were supplied by NDEA, Title III.

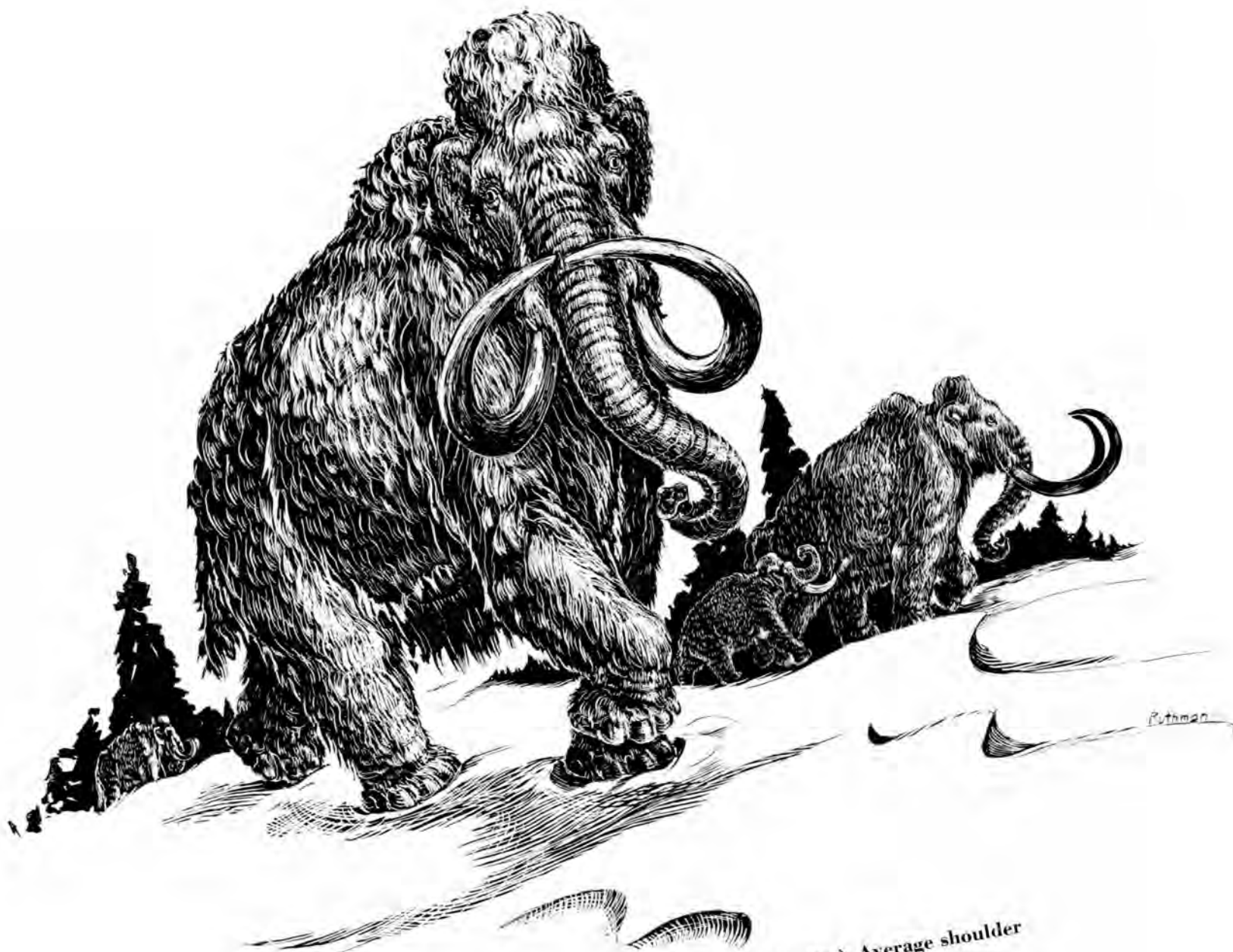


FIGURE 1. Woolly mammoth (*Mammuthus primigenius*). Average shoulder height 9 feet.

INTRODUCTION

Since early colonial times, the bones of mastodons and mammoths have been recovered from the swamps and gravel pits of New York. These fossils are the remains of two different species of elephants which inhabited the area during the Ice Age or Pleistocene Epoch, which ended about 11,000 years ago. During that time, mastodons and mammoths, together with smaller, less exotic animals, flourished and then mysteriously became extinct.

The woolly mammoth (*Mammuthus primigenius*) roamed over Europe, Northern Asia, and North America during the last half of the Pleistocene. It resembled an elephant, with an enormous head, high shoulders, and sloping back. (See figure 1.) Its long curved tusks contrasted with the dense coat of dark brown hair and yellowish wool which protected it from the cold. The pillarlike legs and broad feet of the mammoth enabled it to move easily over boggy ground to graze on tundra grasses. Descriptions of the mammoth are based on frozen carcasses which have been found in Siberia and Alaska. The name mammoth may be derived from "mama'nta," or earthmouse of Tartar origin. Finding the bodies of mammoths in the frozen ground, the Tartars believed they belonged to creatures which burrowed beneath the ground and died when they came too near the surface. The earliest accounts of mammoths have been lost, but their tusks formed the basis of the northern ivory trade for centuries. The mammoth was one of the first mammalian fossils to be found by man, and the only extinct elephant of which the soft parts are known. Mammoths were hunted by cave men, who left spirited drawings of them on the walls of caves in France and Spain.

Compared to the woolly mammoth, the mastodon (*Mastodon americanus*) had a flattened head and a longer, more rectangular body. (See figure 2.) Its tusks were shorter, and some individuals had a pair of small straight tusks in the lower jaw. The mastodon was probably covered with coarse brown fur. Like other elephants, it was a large animal; it is estimated to have weighed between 5 and 6 tons. The mastodon browsed on the evergreen foliage of glacial and postglacial forests of North America, Siberia, and Central Russia. Although it was most abundant in the eastern part of our country, its bones are found in Michigan, Iowa, and the Carolinas. The name mastodon is from the Greek *mastos*—breast, *odous*—tooth. It was applied to the animal by Baron Cuvier, a French scientist, who thought the prominent cusps of its molars resembled human breasts. The first recorded mastodon fossils in New York, some molar teeth, were discovered in 1705 in Claverack, Columbia County. The animal's preference for a swampy habitat, as well as good conditions for preservation, account for the number of fossils found in the State.

MASTODONS AND MAMMOTHS ICE AGE ELEPHANTS OF NEW YORK

FOSSILS AND FOSSILIZATION

By definition, a fossil is any trace or remain of an organism that lived during prior geologic time which is buried in the soil or in the rocks of the earth's crust. The earliest known fossils date from the Precambrian Era, which began about 4,500 million years ago. (See figure 3.) Fossils include molds, casts, impressions, footprints, teeth, and bones. Fossils are found in sedimentary rock or in unconsolidated sediments deposited by wind, water, and glaciers. Organisms form fossils by fortunate accident; probably 99 per cent of all past life on earth has vanished without a trace. The bodies of most animals are destroyed soon after death by decay and scavengers. Any organism which is quickly buried by protective sediment may become a fossil.

As with all fossils, the mastodon and mammoth remains represent a very small portion of the total population which existed over a long period of time. Geologically speaking, they are comparatively young; they date from the Pleistocene Epoch which began about a million years ago. (See figure 3.) They were embedded in unconsolidated fresh-water sediments like clay, marl, sand, and gravel. (See figure 7.) The finer sediments, clay and marl, provide the best preservation. Marl is a limy clay which is often formed in cold fresh water by the precipitation of calcium carbonate. These water-laid sediments inhibit decay by sealing off oxygen. Mastodon bones are often found in peat bogs, where humic acids are effective in inhibiting decay. In New York, bones and teeth are usually the only parts preserved of mastodons and mammoths. However, crushed twigs, the possible remnants of a final meal, have been found within the rib cage and adhering to the teeth of mastodon skeletons.

Frozen mammoths have been found north of 60° N. latitude in the perma-frost regions of northern Siberia and Alaska. Of the several frozen specimens found in Siberia, four were reasonably complete; these had the hair, skin, soft tissues, stomach contents, and blood

preserved. Contrary to popular opinion, these mammoths were not as fresh as quick-frozen meat from a freezer. All of them showed evidence of extensive decay. Only one human is known to have tasted mammoth meat; he found it highly unpalatable. The animals appeared to have been in good health at the time of their deaths. Apparently they perished quickly; possibly by drowning, falling into gullies, or being buried in mudflows. The proportion of those found frozen (39) to the estimated total population (50,000) is so small that there is no reason to believe that they were killed by a widespread catastrophe.¹

PROBOSCIDEA

Mammoths, mastodons, and elephants belong to a large division of mammals called the Proboscidea (pro-bo-sid-e-a) from the unique proboscis or trunk which hangs from the forehead. There are only two living representatives, the Indian elephant (*Elephas maximus*) and the African elephant (*Loxodonta africana*); the majority of species of the large order are known only through fossils. As reconstructed, some bear little resemblance to living elephants. The Proboscideans lived in a wide variety of climates on all the continents except Australia and Antarctica. They may have originated in Africa; the earliest known fossil (*Moeritherium*) was found in Eocene strata of Egypt. Members of the order migrated to Europe and Asia during the Miocene Epoch, about 20 million years ago. Later, some reached North America via a land bridge which existed across the Bering Sea.

¹ W. F. Farrand, 1961, "Frozen Mammoths and Modern Geology", *Science*, v. 133, No. 3455 (March 17).

One of the best preserved of the frozen specimens, the Bere-zovka mammoth, is on display in the Zoological Institute, Academy of Science, Leningrad, U.S.S.R. The American Museum of Natural History in New York City has parts of a frozen baby mammoth which were washed out of a gravel bank near Fairbanks, Alaska, in 1948.

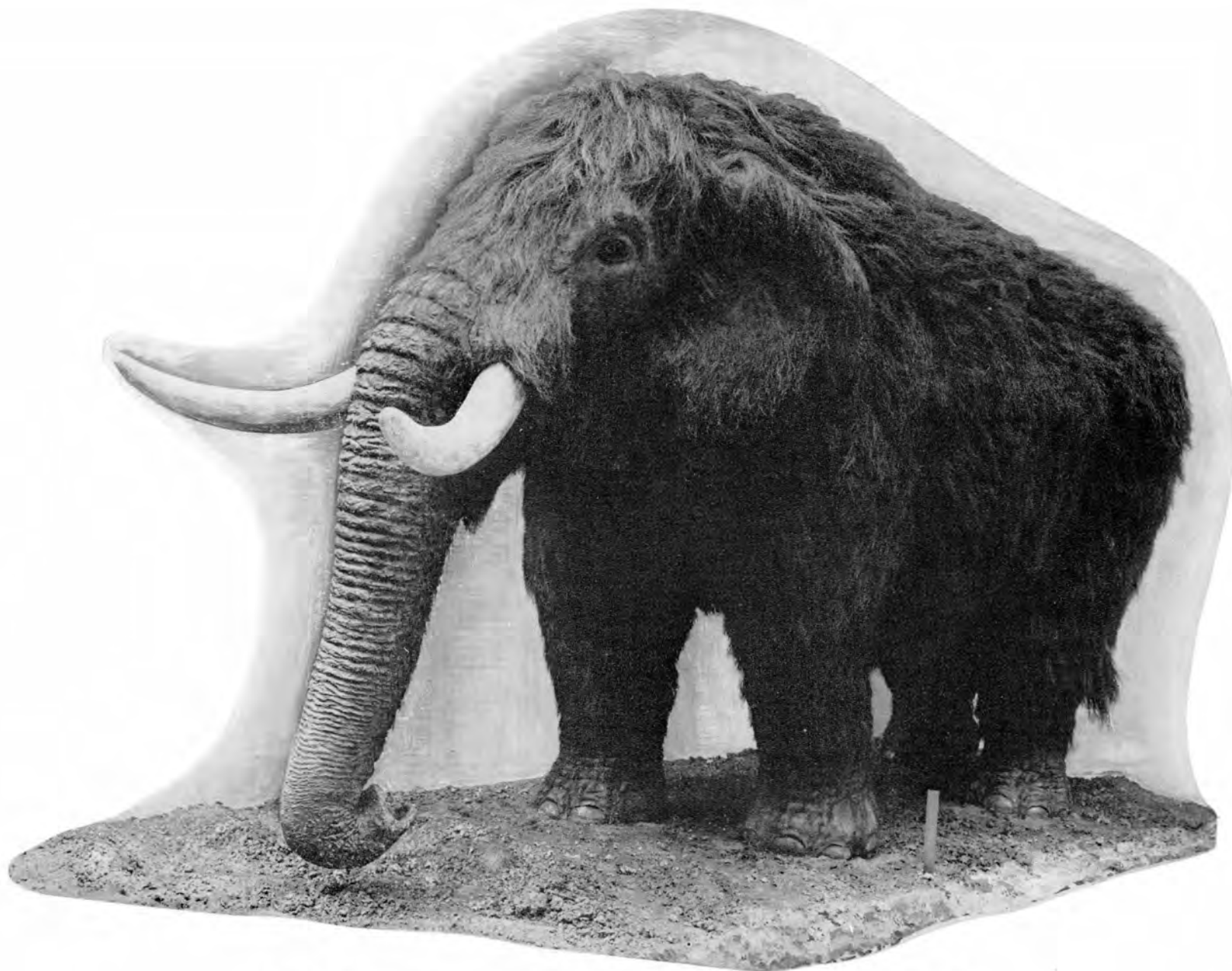


FIGURE 2. American mastodon (*Mastodon americanus*). Average shoulder height 9 feet. Life-size restoration on exhibit in the State Museum at Albany.

Eventually they occupied South America. The Pliocene and Pleistocene Epochs were the time of their greatest diversification and geographical distribution.

The characteristic muscular trunk of Proboscidea, an elongated nose, is an adaptation which also enables these large, tall animals to obtain food and water without kneeling on the ground. The trunks of the woolly mammoth and the living elephants have one or more fleshy projections (processes) on the tip; these are used for grasping small objects.

The massive bodies of the Proboscidea must be supported by strong skeletons. All long bones of the skeleton lack marrow cavities; the marrow is distributed in cells in spongy bone. This arrangement increases the strength of the bones without increasing their weight. The legs, also adapted for strength, are columnar with proportionately long upper segments and exposed knee joints. In comparison, the horse, an animal adapted for speed, has limbs with short upper segments and a knee joint concealed by flank muscles. Proboscidean feet are short and broad. Modern elephants seem to walk on their toes, but the foot is really supported by a large pad of elastic tissue beneath the heel.

The Proboscidean skull is large in proportion to the body. In addition to protecting the brain and other sense organs, it supports heavy tusks and molars and provides attachment for trunk, jaw, and neck muscles. The trunk muscles are attached around a large nasal opening in the center of the forehead. The skull is bulky, but its weight is reduced by numerous cavities or sinuses between the layers of bone.

Teeth are the most common remains of fossil Proboscidea, since they are more durable than bone. They vary significantly according to species, and hence are important in identification. The teeth are highly specialized. Mammals have two sets of teeth, milk and adult, which vary in shape and are arranged in the jaw according to function. Tooth types are: (1) incisors—sharp, nipping teeth, (2) canines—long, piercing teeth, (3) premolars—shearing, cutting, and slicing teeth, and (4) molars—crushing teeth. Molars and premolars are often similar in shape.

The number and type of teeth of a mammal are expressed in a dental formula with an appropriate letter representing the tooth type. Since mammals are bilaterally symmetrical, the formula expresses one side of the upper and lower jaw, beginning from the center front. Thus, the formula for an adult human is:

$$I\ 2/2, C\ 1/1, P\ 2/2, M\ 3/3 \times 2 = 32$$

The Proboscidea have lost the canines and most of the incisors. The remaining incisors have become enlarged to form tusks.

Mammalian teeth are composed of three substances; enamel, dentine, and cement. Enamel is the hardest of all animal tissues and resists decay. Dentine is a softer tissue which is chemically similar to bone. It is filled with an immense number of fine nerve fibers which make the teeth sensitive. Cement is softer than dentine and more resistant to decay. These materials are arranged differently in two types of molar teeth. In brachyodont (low-crowned) molars like those of mastodons, cats, and humans, the crown of the tooth projecting above the gum is covered with enamel, the bulk of the tooth surrounding the pulp cavity is dentine, and cement covers the roots. (See figure 4.) The brachyodont molar is graphically and colorfully illustrated on dental health charts. Mastodon molars are well adapted for chewing evergreen twigs and branches. Cows, elephants, and mammoths have hypsodont (high-crowned) molars in which the enamel is arranged in vertical folds which enclose dentine. Cement fills the spaces between the folds and covers the exterior of the tooth. As the grinding surface is worn down, all three substances of varying hardness are exposed. More tooth gradually emerges from the gum as the surface is worn down. (See figure 5.) The hypsodont molar with its large renewable grinding surface is adapted to a grass diet. Grass contains silica, a hard substance which erodes teeth. If a man, disregarding palatability and nourishment, ate grass for a year, his teeth would be completely worn down.

The conspicuous tusks are rootless and evergrowing. They are composed entirely of dentine, except for a cap or spiral band of enamel. Some fossil Proboscideans used their tusks to obtain food, but the living wild elephants seem to use them mainly for defense.

As mentioned before, the mastodon has brachyodont molars. The crown of the molar is formed of a varying number of cone-shaped cusps arranged in transverse ridges, with two cusps composing a ridge. (See figure 4.) The ridges of the upper and lower molars interlock and crush food between them. The mastodon has two molars in each side of each jaw at a time. The teeth emerge vertically, but once in place the molars move toward the front of the mouth. Each molar is larger than the preceding one. The first three molars which pass through each jaw half are technically milk teeth (Dp in a dental formula). The complete dental formula for the American mastodon is:

$$I\ 1/0, Dp\ 3/3, M\ 3/3 \times 2 = 26$$

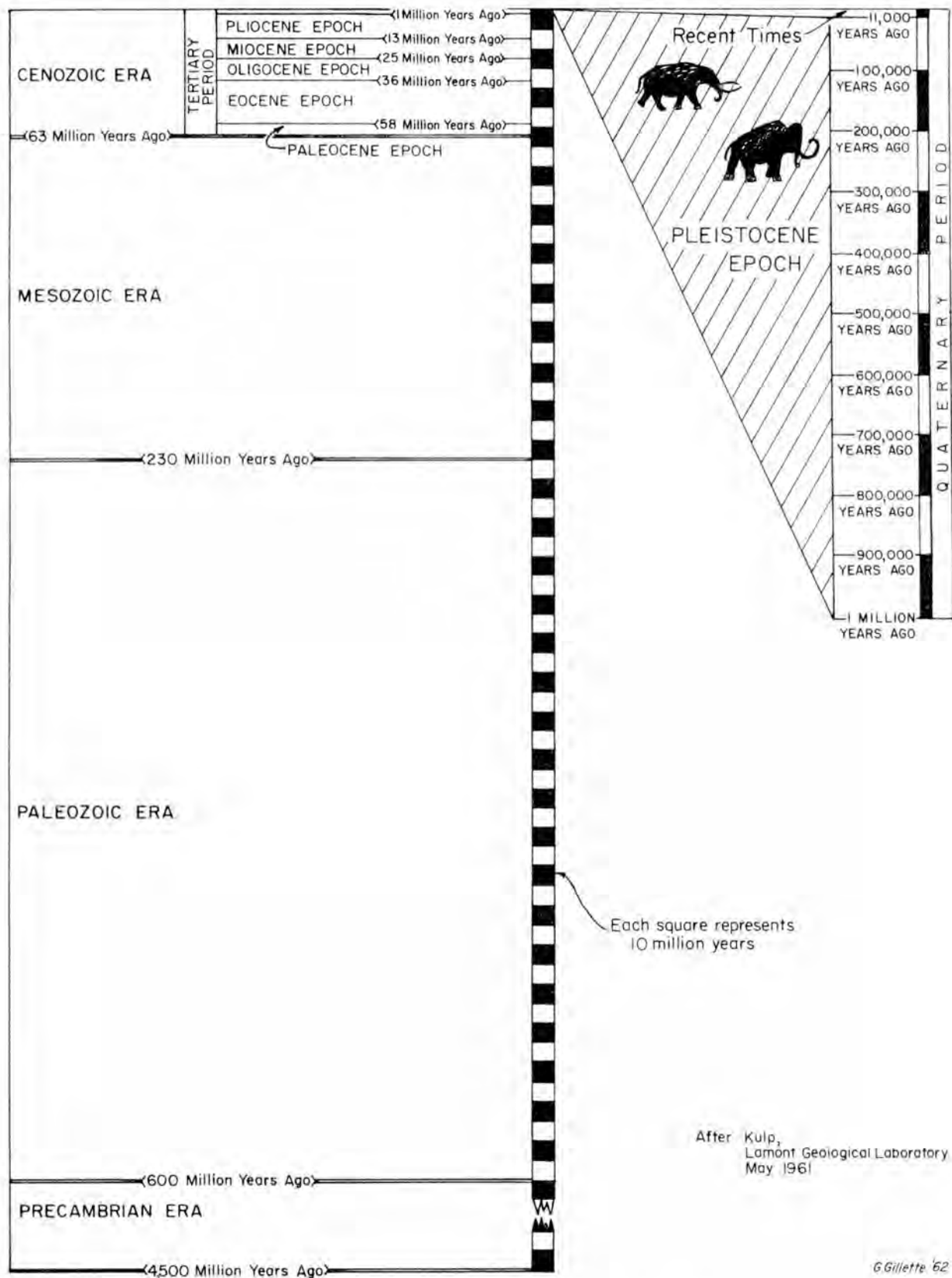


Figure 3. Geological Time Scale

The mastodon had 24 molar teeth during its lifetime. Mastodon tusks are moderately curved, although in old males they are massive and strongly curved. A few mastodon skulls have been found with a small pair of tusks in the lower jaw.

In comparison with the mastodon, the mammoth skull is very short from back to front. As in the living elephant, there is only room for one molar in each jaw half at a time. Each molar emerges at an angle from the back of the jaw, and as it is worn down, it is gradually pushed toward the front of the mouth. By the time the entire molar has emerged, the front section will be worn down to less than half the height of the back. When the molar is reduced to a small fragment, it is pushed out by the tooth behind. (See figure 5.) Each successive molar is larger, with more enamel plates than the one before. The final permanent molar of the woolly mammoth has 24 enamel plates. The dental formula is the same as the American mastodon. The tusks of mammoths are longer and more curved than those of the mastodon; the longest mammoth tusk found was almost 16 feet long.

ICE AGE NEW YORK

Mammoth and mastodon fossils are found in ice age or Pleistocene glacial sediments and peat bogs. During the Pleistocene Epoch, which began a million years ago, there were at least four major glacial advances separated by intervals of warmer climate known as interglacial periods. Plants and animals occupied the areas abandoned by the glaciers during the interglacial periods. The last great glacial advance occurred sometime during the past 30,000 years. Most of the glacial deposits and features in New York State date from this advance, since each glacier tends to obliterate evidence of earlier ones. Some scientists feel that we are now in a warm interglacial period.

The last ice sheet that covered much of North America is divided geographically into two parts. The portion west of the Rockies was the Cordilleran Ice Sheet. The Laurentide Ice Sheet, with which we are concerned, occupied eastern and central Canada and northeastern and central United States east of the Rockies. At its maximum extent, it covered more than 4,800,000 square miles, including all of New York except the southern half of Long Island.

A glacier has been defined as "a body of ice and firn consisting of recrystallized snow and refrozen meltwater, lying wholly or mostly on land and showing evidence of present or former motion."² A glacier begins high on a mountain slope where the summer heat fails to melt all

of the snow from the preceding winter. If the climate remains unchanged, more snow accumulates each year. The snow, by melting and refreezing, changes to firn, a granular snow like that seen in old snowdrifts toward the end of the winter. Over a period of years, the firn gradually changes to ice. The lower edge of the glacier, under pressure from the weight of the snow and ice above it, flows slowly outward. A glacier which starts on a mountain slope moves down into a valley. At this stage, it is a "valley glacier." It is thought that during a glacial advance, valley glaciers coalesce to cover lowlands. These more extensive glaciers are "piedmont glaciers." Gradually, the piedmont glaciers thicken and extend until they form an ice sheet which engulfs most or all of the mountain summits.

The lower surface of the glacier in contact with land breaks and scrapes off bits of rock and soil and carries them along in suspension. When this debris is deposited from the glacier either directly or by meltwater streams, it is called drift. As the glacier moves, the rock fragments rub against each other and against the bedrock beneath. The bedrock surface, depending on its composition, is scratched, gouged, and furrowed by the abrasive fragments. According to size and durability, the fragments are smoothed into rounded boulders and cobbles or reduced to gravel, sand, and clay.

Besides quarrying and transporting rock fragments, the glacier molds the surface beneath it. Among the land forms created by actively flowing glaciers are small elongate hills called drumlins. These are formed as a glacier flows over its own deposits or over sediments deposited by an earlier glacier. The long axis of a drumlin parallels the local direction of flow of a glacier. One of the drumlin fields formed by the Laurentide Ice Sheet is an extensive field of 10,000 in central western New York State. This may be observed between Syracuse and Rochester along the New York State Thruway.

The glacial retreat was gradual; it probably extended over a period of several thousand years. Small glaciers lingered in the mountain valleys after the major lowland portion had disappeared. Meltwater streams formed around and under the ice, creating various formations of sand and gravel. The drift held in the glacier was released irregularly over the surface to form a ground moraine characterized by small hills separated by depressions. Large blocks of ice broke off the glacier and

²R. F. Flint, 1957, *Glacial and Pleistocene Geology*. John Wiley & Sons, Inc., New York, p. 11.

were buried in the drift. When these blocks finally melted, the covering sediment collapsed into distinctive kettlelike depressions in the ground; an area where these are numerous has kettle and kame or kettle and knob topography.

The ice sheet destroyed many river drainage systems and created numerous lakes. In the central and western part of the State, a series of lakes was formed when the water from north-flowing streams was trapped between the ice front and the high land to the south. (See figure 6.) The lakes fluctuated in size and location during the slow stages of the glacial retreat. The Ridge Road between Rochester and Lewiston is built on one of the offshore bars of one of these lakes. To the east, Lake Albany, another series of lakes, was formed when stagnant ice blocked the lower Hudson Valley. Meltwater from the glacier emptied into the lake through the Mohawk Valley and deposited beds of sand and clay. The immense weight of the ice depressed the land enough to allow sea water to enter the Lake Champlain area and the eastern end of the present Lake Ontario basin. After the ice had melted in postglacial times, the land slowly rose and the water subsided.

POSTGLACIAL NEW YORK — TUNDRA

The landscape along the border of the glacier seemed desolate. Low tundra vegetation, lichens, mosses, grasses, and sedges interspersed with dwarf willows and birches grew over the ground exposed by the melting ice. In the summer, the ground was saturated with meltwater from the remnants of ice that lingered in the hills and sheltered valleys. The climate was probably cold and stormy like that which prevails today in tundra areas around the polar ice cap in northern Europe, Asia, and North America. As the glacier retreated north across the State, the tundra border advanced. Tundra was gradually replaced by scattered, stunted spruce trees and finally by a dense evergreen forest.

The woolly mammoth inhabited the tundra along the glacial borders. Its remains have been found associated with typical tundra plants and animals in other parts of the world. The well-preserved frozen specimens from Siberia show that the mammoth had heavy fur and a layer of fat beneath the skin, both adaptations for extreme cold. The Berezovka mammoth, discovered near the Berezovka River in northern Siberia in 1899, had a quantity of undigested food in the stomach. This mass contained remains of grasses, sedges, the alpine poppy, and the buttercup. Other discoveries indicate the mammoth fed on dwarfed birch, arctic willow, and reindeer moss, all plants which grow in or near the tundra today.

MAMMOTHS IN NEW YORK

Mammoth remains have been found, with a few exceptions, only in the central and western portions of the State. (See figure 6.) Comparatively few remains have been reported, and they have been very poorly preserved. Either the mammoths never attained great numbers in the area, tundra was neither extensive nor enduring in New York, or favorable conditions for their preservation did not exist here. Mammoth fossils are usually found in sand, clay, and gravel deposited near borders of the glaciers.

During construction of the Erie Canal in 1825, workmen found mammoth remains near Chittenango, Madison County. Apparently the skeleton was quite complete, but souvenir hunters carried off many of the bones. Among the parts recovered and placed in the State Museum are the tusks, three teeth, some ribs, foot bones, and part of the lower jaw. No detailed information about the location or circumstances of the find is available, but the bones were probably buried in glacial drift.

Fragmentary remains of two mammoths were found in 1912 in a large sand and gravel pit at Lewiston, Niagara County. The extensive gravel deposit is part of a spit formed by waves and currents in a glacial lake. The spit extends west through the village of Lewiston. The mammoth bones were scattered through the pit from depths of 20 to 30 feet below the surface of the ground. At least 35 bones were found, most of which were too badly broken or crumbled to be identified. The remains included two atlases, a pelvis, broken ribs, a vertebra, foot bones, two broken molars, and one complete molar.

A mammoth tooth was found 22 feet underground in a layer of sand and clay during excavation for Barge Canal Lock 26, 2½ miles east of Clyde, Wayne County, in 1910. These deposits southeast of Clyde are a delta formed in a glacial lake.

In 1916, at Savannah, a few miles east of Clyde, mammoth remains were dug from a gravel pit on the west side of a high drumlin, a mile northwest of the town. Two teeth, a shoulder blade, and fragments of leg and foot bones were recovered. The drumlin is isolated in the Montezuma marshes. During the glacial lake period, the drumlin was an island with the nearest land, another island, over a quarter of a mile away. The mammoth bones were found in one of the beach spits built on the drumlin by the waves. Apparently, the bones were deposited in the gravel by the waves, since they are mixed with the beach sediments. The mammoth may have

reached the island by swimming or by crossing the ice in the winter. He may have drifted over on an iceberg broken from the glacier, or possibly the bloated mammoth carcass floated to the island and became stranded on the beach.

One of the few mammoth specimens found outside central and western New York is a molar which was dug from a well or cellar excavation on the farm of John Harris in Upper Queensbury, Warren County, sometime prior to 1860. Unfortunately, no details were recorded. Upper Queensbury borders Lake George along the southern tip and for a few miles along the eastern shore. During the period of the glacial lakes, this valley was occupied by a river which drained meltwater from a lobe of the ice sheet into the Hudson. (See figure 6.)

RANDOLPH MAMMOTH

The most complete mammoth from the State was discovered in 1934, at Randolph, Cattaraugus County. The skull, tusks, lower jaw, several ribs, vertebrae, and leg joint bones were recovered. The skull and tusks are largely intact and in excellent condition. The tusks together weigh 145 pounds and measure, along the outside curve, 9 feet 4½ inches and 9 feet respectively. The skull is 4 feet long and weighs 195 pounds without the lower jaw. It is now in the State Museum collections. (See figure 8.)

The Randolph mammoth was found at the center of a filled pond about 210 feet in diameter which was originally a small kettle hole. The animal apparently wandered too near the edge of the pond and became mired. Parts of the carcass slumped into the pond and were preserved. The locality, 4 miles from a horseshoe bend of the Allegheny River, is in a broad flat valley now occupied by Little Conewango Creek. Before the Pleistocene, the Allegheny flowed northwest through the valley toward Lake Erie. The glacier filled the valley with several hundred feet of drift, diverting the Allegheny to its present course south through Pennsylvania.

KITCHIWAN MAMMOTH

In May 1961, a thighbone, two rib fragments, and three vertebrae of a Jefferson's mammoth (*Parelephas jeffersonii*) were found near Kitchiwan, Westchester County, near the intersection of New York 134 and the Taconic Parkway. During the course of construction to relocate Route 134, a peat bog was excavated to provide a stable roadbed. The gigantic (49½ inches long) thighbone was scooped up by a mechanical bucket. The exact location of the remains is unknown; the other bones were

recovered from a dump site of excavated blue clay and peat. Probably the bones were buried in sediment below the layer of peat. Jefferson's mammoth, named after Thomas Jefferson, was larger than the woolly mammoth; it was a maximum of 10 feet 6 inches high at the shoulder, compared with a maximum shoulder height of 9 feet 3 inches for the woolly mammoth. This discovery is important because it is the first Jefferson's mammoth found in New York, as well as the first mammoth recorded from Westchester County.

In addition to the mammoth remains mentioned, mammoth molars have been found in Olean, Chemung Narrows, Elmira, Rome, Buffalo, Salina, and Minoa. Most of these had little or no data recorded with them.

POSTGLACIAL NEW YORK — EVERGREEN FOREST

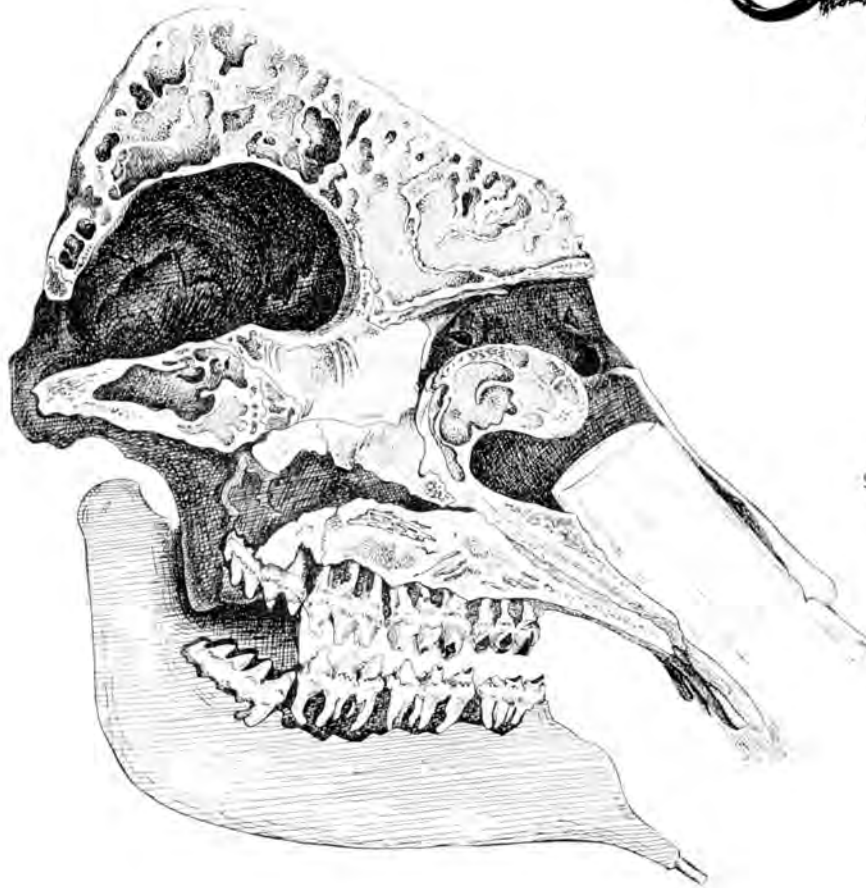
During later postglacial time, the tundra belt was succeeded by an evergreen forest which included spruce, pine, fir, hemlock, and larch. Perhaps birch, aspen, and dwarf rhododendron grew along the streams and on the slopes. In later postglacial time this forest extended over the State. Herds of mastodons browsed among the trees and drank from the streams. Moose, elk, peccary, and a giant bear also inhabited the area. Undoubtedly, other animals lived in the forest, but their remains have not been found.

POLLEN ANALYSIS

Pollen analysis has provided evidence of the postglacial forest. When trees and other plants flower, they shed great quantities of pollen which is dispersed by the wind. Pollen which settles in lakes or in bogs is incorporated in lake sediments or peat. Pollen grains are very durable, both chemically and physically. Some can be identified as to genus; others, as to species or subspecies. The pollen grains are useful fossils since they indicate communities of plants, and hence the climate that prevailed when they were deposited. To obtain the pollen, core borings are made in lake floor sediments or in bog peat. In the laboratory, samples from selected levels are examined beneath the microscope and at least 150 pollen grains are identified in each. The proportion of grains from each kind of plant is treated statistically. The percentage of various types of plants at a given level reflects the plant communities that lived in the area at the corresponding time. The accuracy of this method is confirmed by the fact that the types of pollen found on the surfaces of peat bogs correspond with the surrounding plant communities. The data for various stratigraphic levels are combined in

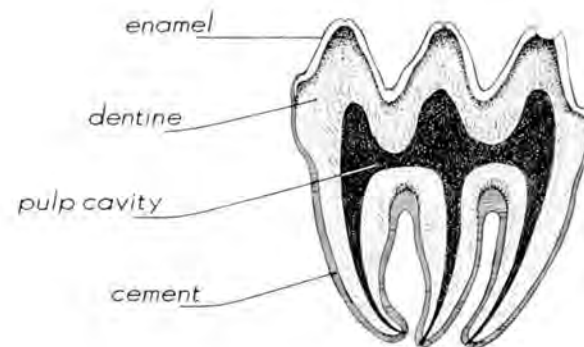
MASTODON

mastodon americanus



sagittal section of
a mastodon skull

molar tooth - exterior



molar tooth - cross section

MAMMOTH

mammuthus primigenius



sagittal section of a mammoth skull

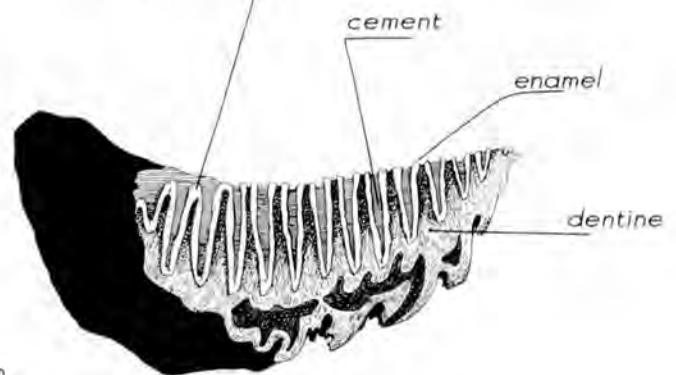
molar tooth – exterior



molar tooth – top view of grinding surface



cement-covered
unworn sections



molar tooth – cross section

Figure 5.

sequence to form a pollen profile in which climatic change is shown. The changes in plant distribution shown in the pollen profile are usually the result of changing climate due to deglaciation. Pollen analysis has been used extensively in Europe and in eastern North America to determine postglacial climates and vegetation.

The pollen profiles from New York indicate that the earliest postglacial forests were evergreen and dominated successively by pine, spruce, and fir. These were followed by a period in which pines dominated. The pines were replaced by a hemlock and hardwood forest, which extends to the present. In general, fir and spruce are considered indicators of a wet, cold climate; pine, a dry, cool climate; and hemlock, a moist climate which may be either warm or cool. Since the glacial retreat, the climate in the State has fluctuated with regard to moisture and temperature.

In 1955, Myles Colgan uncovered mastodon bones while constructing a pond on his farm near King Ferry, Cayuga County. Core samples were taken from the site at which the mastodon was recovered. The pollen profiles indicate that the mastodon lived in a predominantly spruce and pine forest. In this case, pollen analysis provided evidence of the mastodon's habitat. Several New York mastodon skeletons have been found associated with masses of crushed twigs but unfortunately, the vegetable matter was usually scattered and lost before it could be identified.

MASTODONS IN NEW YORK

The remains of over a hundred mastodons have been recorded from New York State. (See figure 6.) Of these, only a few were complete skeletons. The majority of mastodons was found in Orange County, in the southeastern part of the State. During the 19th century, when some of the best specimens were discovered, the mastodon was considered an unknown, rather terrible animal. Vertebrate paleontology was in its infancy, and arguments were waged over the identification of the enormous bones. The New York skeletons, the first complete ones collected, contributed to the knowledge and classification of the animal. They caused much excitement among naturalists and the public of the times, an acclaim reserved today for specimens of the larger and more imposing dinosaurs. This excitement is reflected in the early written accounts and disappears in the reports of the later finds when the mastodon became better known and large collections of the bones had accumulated. Some of the circumstances of the later discoveries have proved interesting, however, and future finds, if carefully excavated,

may provide answers to unsolved questions about the mastodon's life history.

The following account of mastodons found within the State is by no means complete. Only those discoveries which are significant for the date and location, the circumstances, or persons involved have been mentioned. A list of all mastodon and mammoth remains reported from New York to 1922 is contained in *New York State Museum Bulletin 241-42*; later finds are recorded in the State Museum files.

The earliest printed account of the discovery of mastodon remains anywhere appeared in the *Boston News Letter*, July 30, 1705:

"New York, July 23. There is a prodigious (sic) Tooth brought here, supposed by the shape of it to be one of the four great Teeth of a man; it weighs four pounds and three quarters, the top of it is as sound and white as a Tooth can be, but the Root is much decayed, yet one of the fangs of it holds half a pint of liquor; it was lately dug up, a great way underground on the side of a Bank or Hill, 30 or 40 foot above it, at or near a place call'd Claverack, about 30 miles this side of Albany, and is looked upon here as a mighty wonder, whither (sic) the Tooth be of Man or Beast. They also dug up several bones, which as they came to the air crumbled away: They say one of them which is thought to be a Thigh-bone was 17 foot long. There is since another Tooth taken up in the same place, which is a Fore Tooth flat and broad, and is as broad as man's Four Fingers, which I have not yet seen; but the other I did see, and t'was brought here by a gentleman of the Assembly: They dug up several Trees in the same place of great bigness."

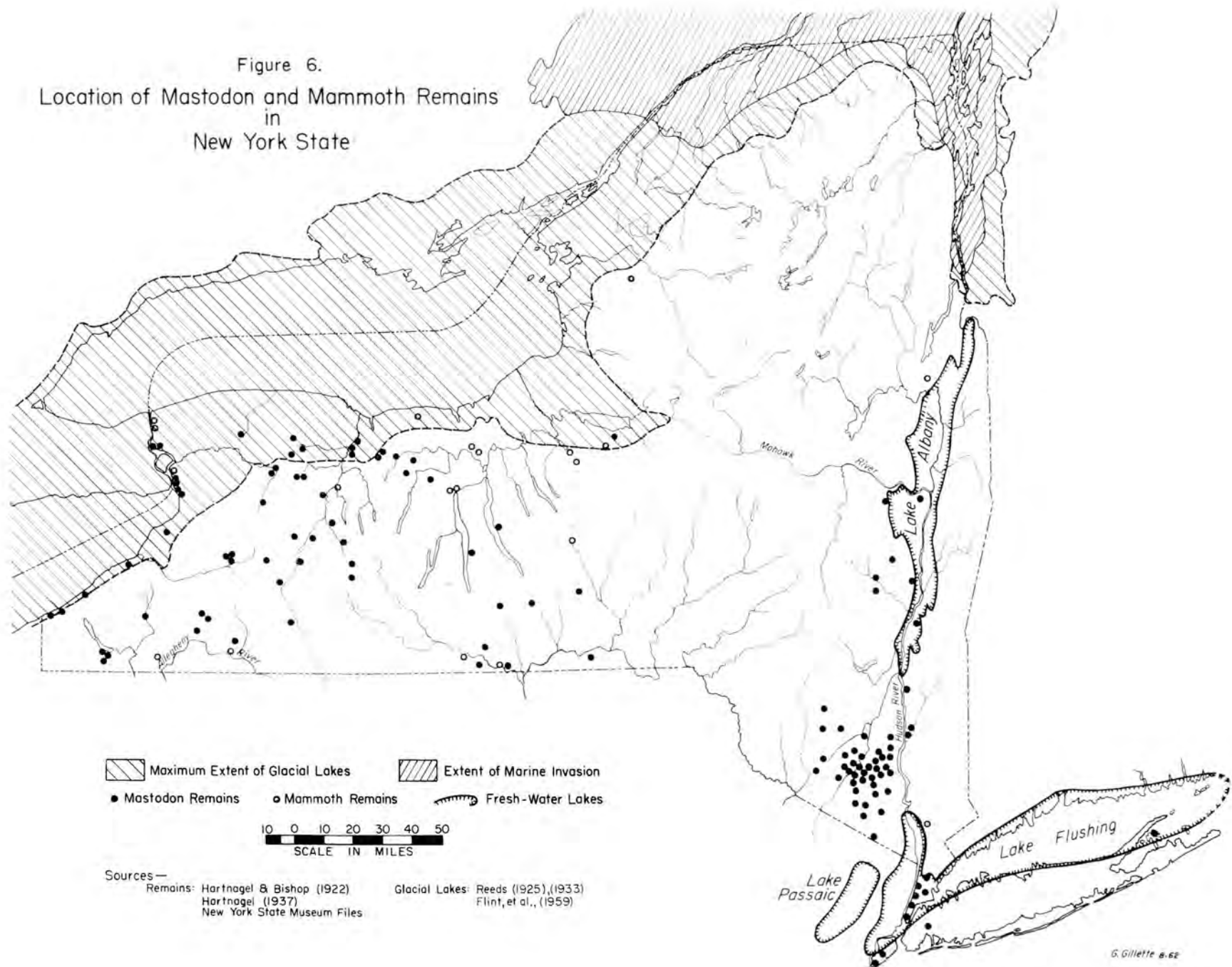
The length of the thighbone was greatly exaggerated. The Claverack tooth was found by a Dutchman who sold it to a member of the State Assembly, one Van Braggen, for a gill of rum.

In 1706 near Coxsackie, N. Y., another tooth with some bone fragments was found on the bank of the Hudson, where a spring freshet had exposed them. Governor Joseph Dudley of Massachusetts wrote a letter to Cotton Mather in which he stated that the tooth was undoubtedly that of one of the giants mentioned in the Old Testament who had been drowned in the Flood.

Cotton Mather's name is most frequently associated with witchcraft, but he was a prolific writer on many topics. At one time he planned an extensive work relating various Biblical passages to certain wonders of American natural history; he mentioned Dudley's interpretation of the mastodon tooth as an example. These men realized that the tooth belonged to an animal which

Figure 6.
Location of Mastodon and Mammoth Remains
in
New York State

17



lived a long time ago, although later scientists would disagree about the kind of animal.

In the fall of 1780, four teeth, vertebrae, and leg bones of a mastodon were found during ditching operations on the property of Rev. Robert Annan on the banks of the Wallkill River some 3 miles south of Montgomery, Orange County. Many bones were uncovered, but most were too badly decayed to be removed. Gen. George Washington viewed them in 1782-83 while he was camped at Newburgh. After the treaty of peace, Dr. Frederick Michaelis, Physician-General to the Hessian troops, came to dig and obtained some bones which he took to Germany. Reverend Annan wrote an account of the discovery for the American Academy of Arts & Science Memoirs in 1793, entitled *An Account of a skeleton of a Large Animal, found near Hudson's river*.

In 1800, part of a mastodon skeleton, including a badly broken skull, was uncovered in the town of Shawangunk, Ulster County. A few months after the discovery, Thomas Jefferson, then Vice-President of the United States, obtained the lower and upper jaws with the molars of this specimen which he later presented to the University of Virginia. Although Jefferson was not a paleontologist, he aided paleontology by collecting specimens, making them available to scientists and exchanging information. In a period when most Americans regarded the collection of old bones as a useless and foolish hobby, Jefferson's personality and position gave paleontology a welcome respectability. Among other scientific activities, Jefferson served as President of the American Philosophical Society (1797-1814) and as President of the Board of Trustees of Peale's Philadelphia Museum.

The founder of this museum, Charles Willson Peale (1741-1827), was a gentleman of many and diverse talents. Although he is best known for his numerous portraits of George Washington, he studied saddlery, engraving, wax modeling, plaster casting, natural history, and taxidermy.

PEALE MASTODONS

In 1799, large bones were found on the farm of John Masten, near Newburgh, in Orange County. Excavation was begun and progressed with the aid of a hundred neighbors and large quantities of rum. Most of a mastodon skeleton was recovered. The swamp where the bones were embedded was fed by numerous springs, the water rose rapidly, and the work was stopped. Anxious to acquire a mastodon skeleton, Peale bought the bones and obtained permission to dig for the remainder. He organ-

ized an expedition to renew excavations in the fall of 1801. His son, Rembrandt (one of 11 children, some named for famous artists) described the venture in his entertaining book *An Historical Disquisition on the Mammoth or Great American Incognitum, An Extinct, Immense, Carnivorous Animal whose Fossil Remains have been found in North America*.³ A large machine was constructed to drain the swamp, the crew labored heartily, and a motley crowd of the curious gathered to encourage them. (See figure 9.) But the banks of the pit caved in repeatedly and only a few small bones and teeth, not enough to complete the skeleton, were found. Peale reluctantly abandoned the site.

About 11 miles from the Masten farm, some mastodon ribs had been found in a swamp belonging to a Captain Barber. The Peales then dug there in the hot sun for 2 weeks and recovered a set of ribs, some teeth, a few vertebrae, 2 tusks, some toe bones, and a broken shoulder blade. The bones were duplicates of those found before and parts of the skeleton, notably the lower jaw, were still missing.

Somewhat discouraged, the Peales rode west from Montgomery to the Millspaw property where mastodon bones had been recovered a few years before. Their probes struck various large objects beneath the ground and work began anew. Ribs, toe, and leg bones, the right shoulder blade, the atlas, part of the head, and finally, a complete lower jaw were uncovered. As Rembrandt Peale described it:

"After such a variety of Labour and Length of fruitless expectation, this success was extremely grateful to all parties and the unconscious woods echoed with repeated huzzas, which could not have been more animated if every tree had participated in the joy. 'Gracious God, what a jaw. How many animals must have been crushed between it!' was the exclamation of all: a fresh supply of grog went around, and the hearty fellows, covered with mud, continued the search with increasing vigour."

Such was the enthusiasm with which the colonists dug up mastodons. These bones, together with those that had been found earlier at the same site, gave the Peales enough material for a complete mastodon skeleton.

In the interval between the Claverack find of 1705 and the Peale discoveries, a quantity of mastodon bones,

³ At the time Peale wrote, a name for the mastodon had not been determined, so he called it a mammoth, although he distinguished between it and the Siberian mammoth.



Diagram of Typical Bog Stratigraphy

*note layer where mammoth or mastodon bones may occur

Figure 7.

tusks, and teeth, mostly from the Big Bone Lick area of Kentucky, had been sent to England and the Continent. No complete or reasonably complete skeleton had yet been found. Numerous scientific studies were made of the material in an attempt to determine the type of animal to which it belonged and whether or not the animal in question was identical with the Siberian mammoth. A French anatomist, Daubenton, in 1764 compared the thighbones of a mastodon, a Siberian mammoth, and a modern elephant, and noted the marked similarities. Although Daubenton incorrectly concluded that the bones represented one species of elephant, he proved scientifically that the fossil bones were not the remains of giant men. The mastodon bones and tusks were accepted as belonging to an elephantlike creature, but the mastodon molars with their conical knobs caused some dissension. Peter Collinson read a paper to the Royal Society of London (1767) in which he concluded that the bones, tusks, and molars all belonged to the same elephantlike animal, a distinct species from any known, and that this animal probably subsisted by browsing on trees and shrubs. The opinion Rembrandt Peale expressed, that the mastodon was carnivorous, originated with William Hunter, an English anatomist, who presented a paper to that effect in 1768. Hunter also expressed the pious opinion that mankind was lucky the voracious beast was probably extinct. Peale improved on Hunter's estimate of the mastodon's diet by stating that it ate "shellfish, turtles, fish and other such animals as might be found in or near lakes."

The bones which the Peales obtained were used to complete two skeletons, the first and third recovered on the expedition. The missing parts in each were carved in wood, using bones from the others as models. When the work was finished, the only parts missing were the top of the head and the end of the tail. The most complete skeleton (Philadelphia skeleton) was mounted and displayed in C. W. Peale's museum accompanied by labels, paintings of the excavations,⁴ and later, framed pages from Rembrandt's book. This skeleton,⁵ the first complete one discovered of a mastodon and the first fossil skeleton mounted in America, caused a popular and scientific sensation. At last it was possible to visualize the mastodon as he might have appeared in life. More important, the bone structure, with minor exceptions, of the animal was now known.

⁴ One of Rembrandt's paintings is in the American Museum of Natural History, New York.

⁵ Now in Geologisch—Mineralogische Abteilung des Hessischen Landesmuseum, Darmstadt, Germany.

The second skeleton was exhibited in England by Rubens and Rembrandt Peale in 1802. There Rembrandt studied art and wrote the book. This skeleton (Baltimore skeleton) was one of the attractions of Rembrandt's Baltimore Museum, which he established in 1814. Dr. John Warren, who will be mentioned later, bought the skeleton⁶ to use in his studies of the mastodon.

The Peale discoveries contributed to the knowledge of the mastodon. Casts of the bones, as well as descriptions, were sent to interested persons. In 1806, when the French naturalist Cuvier published his memoir on fossil elephants, a drawing of the Baltimore skeleton was included and the author acknowledged his debt to the Peales. In this memoir, Cuvier named a new genus of elephants (Proboscidiens), the *Mastodonts*, in which he included the American mastodon. No longer *Incognitum*, the mastodon now had a name.

WARREN MASTODON

A few miles from the sites of the Peale discoveries, the finest and most complete mastodon skeleton ever collected was found on the farm of Nathaniel Brewster, near Newburgh, in 1845. Known as the Warren Mastodon, for Dr. John C. Warren, a distinguished Boston surgeon who was its onetime owner, the skeleton lacks only a few toe bones and the vertebrae of the tail. The locale of the skeleton was a small pond lying within a valley. The successive layers of sediment in the pond were: a layer of peat (2 feet thick), a layer of red moss (1 foot thick), and a layer of shell marl in which the bones were embedded. Judging from the position of the bones, the animal, a large male, died in an attempt to climb out of the mucky pond. In the course of the careful excavation, a mass of broken twigs, grass, and leaves was revealed inside the ribcage. Twigs from this mass were later identified by botanist Asa Gray as hemlock. The skeleton was mounted by a local physician, Dr. Prime, and exhibited in New York City and New England before it was purchased by Dr. Warren. It was displayed in Warren's Museum in Boston. Warren made it the subject of an elaborate memoir, *The Mastodon Giganteus of North America*. Because of its condition, its size, and the amount of published data connected with it, the Warren Mastodon⁷ is used as a basis of comparison with other mastodon skeletons.

⁶ Now in the American Museum of Natural History, New York.

⁷ Now in the American Museum of Natural History, New York.

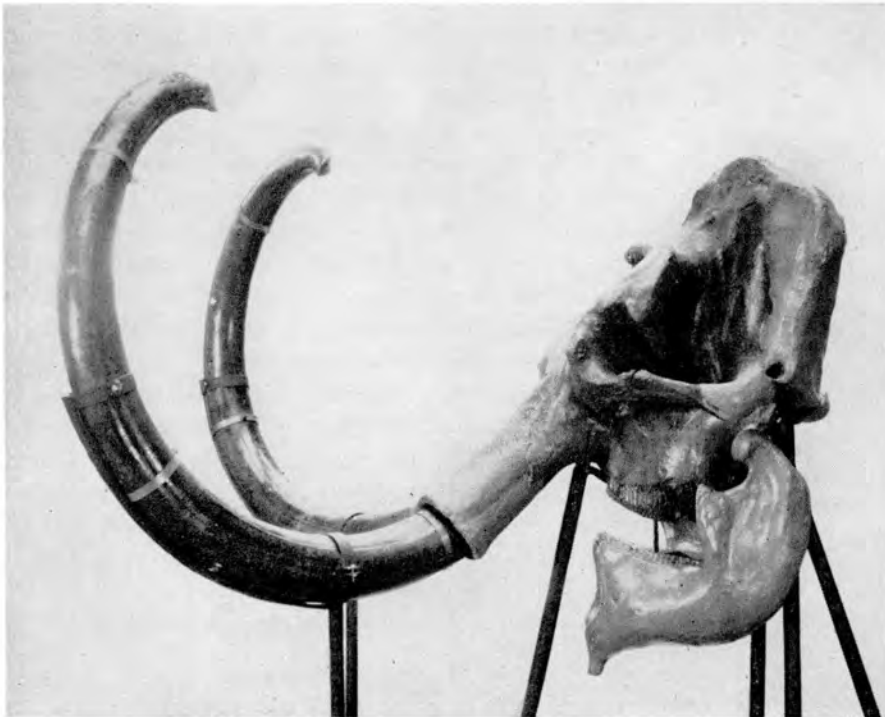


FIGURE 8. Randolph mammoth skull discovered in 1934 at Randolph, Cattaraugus County. Front and side views. Note strongly curved tusks.

Photograph by Jack Sherm

COHOES MASTODON

In September 1866, workmen who were digging for the foundation of the Harmony Mills at Cohoes, Albany County, found the lower jaw and foot bones of a mastodon on a rock ledge within a large pothole on the rock plateau above the Mohawk River, near Cohoes Falls. The surface of the rock in which the potholes lie is almost a hundred feet above the present surface of the river bed below the falls. Excavation continued until the central portion of the pothole was revealed. Here the main parts of the mastodon skeleton lay on a bed of clay, broken slate, gravel, and waterworn pebbles. The head and tusks were unbroken but some of the larger limb bones were missing. In February of the following year, the bones of the right foreleg and foot were discovered in a small pothole more than 60 feet southwest of the site of the rest of the skeleton. All the bones belong to one skeleton since they articulate with each other, some bones are missing, and there are no duplicates. Bits of twigs sticking to the molars were identified as larch, a typical tree of the evergreen forest. The remains are of a young, mature male who suffered from pyorrhea which destroyed the sixth right molar and damaged his jaw. He had shed his lower tusks sometime before his death.⁸ (See figure 10.)

The potholes in which the mastodon skeleton was found are part of a group which occurs in the rock plateau on both sides of the river. Most of these are now filled with clay and peat. During the retreat of the glacier, Cohoes was depressed about 350 feet below its present level. The site of the city was covered with a thick deposit of sand and clay laid down in the bed of glacial Lake Albany. As the ice disappeared, the land rose, Lake Albany was drained, and the ancient Mohawk (Iro-Mohawk) River cut through the sand and clay, reached bedrock, and formed the potholes.

At the time of discovery, there was some controversy over the means by which the mastodon was deposited in the potholes. The most reasonable explanation is that the carcass of the dead animal lay on the flood plain above the holes, the river rose, and swept it into the potholes, which were empty except during periods of high water. The skeleton was certainly deposited long after the potholes had been formed, since the layer of sediment on which most of them rested was over 10 feet thick and 50 feet of muck and peat overlaid the bones.

⁸ The mounted skeleton of the Cohoes Mastodon is on display in the New York State Museum, Albany.

TEMPLE HILL MASTODON

Following a drought in the spring of 1921, a skeleton of a large mastodon was removed from the muck of a former pond on property of Antonio Fisher near Temple Hill, Orange County. The animal probably died mired in the pond, with the head and tusks nearest the surface as if in an effort to keep them above water. The muck at the site varies from 1 to 3 feet in thickness and covers marl of unknown depth. The bones were found within 5 feet of the surface. Masses of broken twigs and plants, the remains of the animal's last meal, were found within the ribs but the material was lost before it could be analyzed. Apparently the animal was young, but full-grown when he died, since 12 molars are present. Some of the ribs, back and tail vertebrae, part of the cranium, and a few toe bones are lacking. The Temple Hill skeleton⁹ is slightly smaller and less complete than the Warren skeleton. (See figure 10.)

C¹⁴ DATING

Until recently, the relative age of Pleistocene fossils was suggested by the geographic location and the type and thickness of sediments in which they were found. However, a method has been developed which allows more precise dating of remains, especially those less than 35,000 years old. The C¹⁴ method depends on the presence of radioactive carbon of the atomic weight 14 (C¹⁴) in organic matter. Ordinary carbon, an element present in all living things, has an atomic weight of 12. Radioactive carbon is created when cosmic rays bombard nitrogen in the earth's atmosphere. Since C¹⁴ behaves chemically like ordinary carbon, it enters with it into the carbon dioxide of the atmosphere. The ratio of C¹⁴ to C¹² in the atmosphere is constant and controlled by rates of supply and disintegration. Living vegetation, in the process of photosynthesis, uses atmospheric CO₂ and thus obtains C¹⁴ and C¹² in this ratio. Animals, whether herbivorous or carnivorous, ultimately derive C¹⁴ from plants. When the organism dies, no more radiocarbon is added. The radiocarbon present in the dead organism will disintegrate so that after 5,760 years only half the original amount will be left, after 11,520 years a quarter, and so forth. The determination of the ratio of C¹² to C¹⁴ in the material provides a clue to its age. The original amount of radiocarbon is so low that the limit of detectability is soon reached. However, specimens up to 85,000 years have been dated. The substances most commonly dated are wood, charcoal, and peat, although bone and

⁹ Mounted and on display in the New York State Museum.

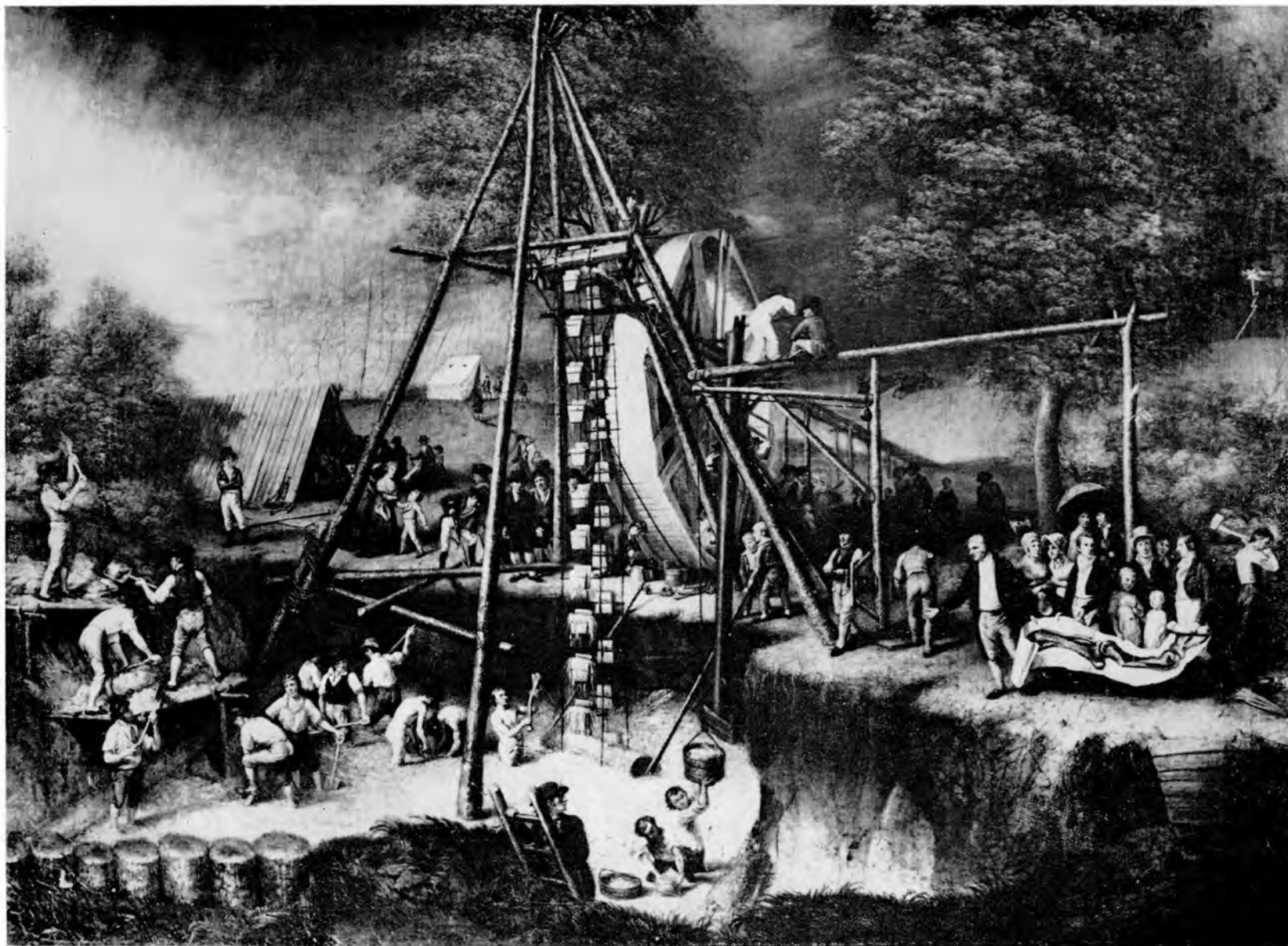


FIGURE 9. "Exhuming the Mastodon" by Charles Willson Peale, 1808. Courtesy of The Peale Museum, Baltimore. The painting depicts the excavation of the first Peale skeleton (Philadelphia skeleton) on John Masten's farm near Newburgh in 1801. The treadmill machine drained water from the swamp.

shells are also used. Carbon from these is refined and the radioactivity measured by a Geiger counter. The method is subject to error, and substances may be contaminated in the ground with younger or older radiocarbon which tends to obscure or falsify the true age. Age determinations are published thus:

13,000 $\pm$ 500 years B.P.

13,000 stands for the determined age; the $\pm$ 500 years means that the chances are two to one that the correct age of the substance lies within that period of time. The initials B.P. stand for Before the Present, the present being the year the determination was made.

The remains of the King Ferry mastodon mentioned before included several molars, part of the lower jaw, a thighbone, parts of the skull, another leg bone, and some toe bones. The one intact tusk recovered measured a record 10 feet 1 inch long. The bones were embedded in a layer of marl and clay. A sample of spruce wood from the level where the clay began was C^{14} dated at 11,410 $\pm$ 110 years B.P. 1957. The wood is assumed to have come from the spruce-pine forest revealed by the pollen profile. In this case, the C^{14} date suggests the age of the associated mastodon specimen. Most of the fossil mammoths and mastodons from New York were discovered before the C^{14} method was developed, so their exact ages have not been determined. However, if future finds are dated, a more accurate record of mastodons and mammoths can be compiled. If several specimens of the animals from different areas of the State were found and dated, it might be possible to determine more precisely the time range during which they lived here.

EXTINCTION

Judging from the number of fossil remains, mastodons were common in the State and mammoths were abundant in other areas of the world during the latter part of the Pleistocene Epoch. Why did they disappear? The exact causes are unknown, but several factors, other than the

destructive activities of man, have been observed to operate toward the extinction of animals. Extinction of any one animal species is probably the result of a number of adverse factors with a cumulative effect. The climate may change radically. A series of severe prolonged winters, for example, would not only weaken and kill the adults by concealing or reducing food supply, but in an area where most mammals bear young in the spring, increase infant mortality. Heat waves or drought would operate in the same manner. As mentioned before, climate change is reflected in vegetation change. If the preferred food plants of an animal disappeared, it might be unable to find acceptable substitutes and starve.

Large animals may compete with smaller, more efficient species for the food supply. Gregarious animals like elephants are subject to epidemics which affect great numbers of one species at the same time. Modern elephants reproduce fairly slowly; a cow may have a calf only once every 3 years. Under optimum conditions, she may produce a dozen calves in her lifetime but multiple births are rare and infant mortality high. A herd which has been reduced by one or several of these factors is more vulnerable to predators. If there are only a few adults, they may be unable to protect the young. These are all factors which may have contributed to extinction of mastodons and mammoths.

Although cave men in Moravia in Eastern Europe killed vast numbers of mammoths, there is, as yet, no conclusive evidence that early man hunted the mastodon and mammoth in New York or contributed to their extinction here. The earliest hunters are thought to have entered the northeast around 7,000 years ago. Clovis fluted points, a type of spearhead made by early man in North America, are sparsely scattered over the State. These points have been found without any animal or cultural remains in New York, although they were found associated with the remains of another species of mammoth (*Parelephas columbi*) in New Mexico. Perhaps future discoveries will establish the presence of early man with the mastodon and mammoth in New York.



FIGURE 10. Mastodon and mammoth exhibit in State Museum. Left to right: Cohoes mastodon (discovered in 1866 at Cohoes), Mastodon restoration, and Temple Hill mastodon (discovered in 1921 at Temple Hill).

NOTICE

The State Museum would like accurate, complete reports of any mastodon, mammoth, or other Pleistocene mammal bones found within the State. Since it is not always possible for a staff member to visit each site, detailed records would be appreciated. Include in the report the exact location, the type of sediments surrounding the bones, the depth of the remains, the bones recovered

with measurements, and, if possible, photographs, diagrams, or maps. Address all correspondence to:

State Paleontologist
New York State Museum and Science Service
Albany 1, N. Y.

Telephone: GR 4-5818

EXHIBIT GUIDE

The mastodon exhibit in the State Museum consists of two mounted skeletons (Cohoes and Temple Hill mastodons) and a life-size restoration of an American mastodon in front of a huge mural of the southeastern Catskills, during the last stages of the glacial retreat. In the landscape painted by Edwin Becker, ice is melting on the mountain slopes, evergreens grow on the hills, and pink rhododendron and white cotton grass bloom along the streams. Mastodons browse in the valley while a large bear watches at one side. A young mastodon stands in the foreground as if he had just walked out of the stream. In the sand around him are numerous footprints of other animals including bear, giant beaver, peccary, wolf, caribou, and whooping crane.

To the right of the mural is a small case which displays two mastodon molars and a map showing the sites of mastodon remains in New York. To the left of the mural is a small exhibit which includes a diagram of

mammoth tooth succession, some mammoth hair, and replicas of plants found in the stomachs of frozen mammoths.

The skeletons, with plaster casts of missing parts, were painted brown to harmonize with the color scheme of the exhibit. The original tusks of the Temple Hill specimen were too heavy for the mounted skeleton and were replaced with replicas of hollow plastic.

The restoration, made in 1922 by Noah Clark and Charles Heidenrich, is the only life-size replica of an American mastodon in the world. It is magnified from a plaster model of the Warren Mastodon by Charles R. Knight. The restoration is a hollow model composed of layers of wire screen and Akeley's mixture (felt paper pulp, whiting, glue, and boiled linseed oil), reinforced by a wooden framework. The feet and trunk were modeled separately and attached to the main body. The hair is dyed sisal fiber.

VITAL STATISTICS

Cohoes mastodon—A young male with a missing molar in the right side of lower jaw

Spinal column, length	15 feet
Height at shoulder, skeleton	8 feet 4¾ inches
Height at shoulder, restoration	8 feet 5½ inches
Pelvis, width	5 feet 5 inches
Thighbone, length	4 feet
Tusks, length	4 feet 6 inches

Temple Hill mastodon — A young, nearly full-grown male

Length, base of tusks to drop of tail	15 feet 1 inch
Height at shoulder	9 feet
Thighbones, length	3 feet 6½ inches
	3 feet 6 inches
Pelvis, width	5 feet 7¼ inches
Tusks, length	5 feet 4 inches

GLOSSARY

- atlas**—the neck vertebra which forms a joint with the skull.
- brachyodont**—the low-crowned molar of mammals in which the crown of the tooth is covered with enamel, the bulk of the tooth surrounding the pulp cavity is dentine, and cement covers the roots. (See figure 4.)
- C¹⁴**—the symbol for radiocarbon or radioactive carbon which has an atomic weight of 14. Ordinary carbon, an element present in all living things, has an atomic weight of 12.
- canine**—the name applied to the conical pointed tooth of mammals. There is one on each side of the upper and lower jaws, between incisors and premolars.
- carnivorous**—an adjective applied to an animal whose diet is composed mainly or wholly of meat.
- cement**—a bonelike substance in vertebrate teeth; usually covers the roots of the teeth and in some mammals, covers part of the crown.
- classification**—organisms are classed scientifically in a hierarchical series of groups. The smallest group regularly used is the species. Species which are more like each other than like other species are grouped together in a genus; similarly, genera are grouped into families, families into orders, orders into classes, and classes into phyla or divisions. The terms plant and animal kingdom are also used, as are various subgroups.
- cosmic rays**—any of the rays of extremely high frequency and penetrating power produced beyond the earth's atmosphere. They bombard the earth from all directions.
- cuspid**—a projection on the biting surface of the mammalian molar tooth.
- delta**—a deposit of sediment formed at the mouth of a river either in the ocean or in a lake. A delta is usually triangular.
- dentine**—a bonelike substance, the main constituent of teeth. Nerve fibers from the pulp cavity penetrate it and make it sensitive. Ivory is dentine.
- drift**—sediment such as boulders, gravel, sand, and clay, transported by a glacier and deposited by it or from water derived from melting glacial ice.
- drumlin**—a small hill, usually elongate, formed when a glacier overrides either its own sediment or sediment deposited by an earlier glacier.
- enamel**—a hard substance which covers the crown of teeth. In some animals, the enamel forms plates within the tooth. Enamel is the hardest animal substance and is highly resistant to decay.
- Eocene Period**—The portion of geologic time which extended from 58 million to 36 million years ago. (See Time Scale.)
- firn**—a granular snow.
- fossil**—any trace of an organism that lived during ancient geologic time. Fossils are found in sediments or in rocks of the earth's crust.
- glacial**—pertaining to glaciers or a period of glaciation.
- glacier**—a body of ice and firn lying mostly or wholly on land and showing evidence of present or former motion.
- hypsodont**—the high-crowned molar of mammals which has no definite root. The enamel is arranged in vertical folds which enclose dentine. Cement fills the spaces between the folds and covers the exterior of the tooth. (See figure 5.)
- incisor**—chisel-shaped tooth in front of mouth of mammals. Tusks of elephants are modified incisors.
- interglacial**—between intervals of glaciation.
- kettle and kame or kettle and knob topography**—an area where there are a number of kettle holes interspersed with small mounds.
- kettle hole**—a basin created by the melting of buried or partly buried blocks of ice near the edge of a retreating glacier.
- mammal**—a warm-blooded vertebrate animal which has hair and secretes milk to feed its young.
- mammoth**—an extinct elephant, similar to modern elephants, characterized by short, high skull and high-crowned grinding teeth.
- marl**—a limy clay which is often formed in cold fresh water by the precipitation of calcium carbonate.
- mastodon (American mastodon)**—an extinct elephant characterized by a long, low skull and low crowned molars with conical cusps.
- Miocene Period**—the portion of geologic time which extended from approximately 25 million to 13 million years ago. (See Time Scale.)
- molars**—the crushing back teeth of mammals. They usually have roots and a complicated pattern of ridges and projections on the biting surface. There are no milk molars.
- paleontology**—the study of fossils.
- paleontologist**—a scientist who studies fossils.
- peat**—accumulated partially decayed plant material which usually forms in bogs and swampy areas.
- peccary**—a small piglike mammal.
- Pleistocene Epoch**—that portion of geologic time which extended from 1 million to 11,000 years ago (see Time Scale). It is sometimes called the ice age.
- Pliocene Period**—the portion of geologic time which extended from 15 million to a million years ago (see Time Scale).
- postglacial**—after glaciation.
- pothole**—a kettle-shaped depression, usually deeper than it is wide, in the bedrock or a stream bed which has been formed by abrasive action of water and rock fragments.
- Precambrian**—the portion of geologic time which extended from 4,500 million to 600 million years ago (see Time Scale).
- preglacial**—before glaciation.
- premolars**—crushing cheek teeth of mammals. They usually have more than one root and ridges and projec-

tions on the biting surface. There are milk premolars as well as permanent premolars.

Proboscidea—elephants, an order of placental mammals. The living species are characterized by proboscis (trunk), large size, pillarlike legs, greatly lengthened incisors (tusks), and huge grinding molars only two pairs of which are in place at the same time.

species—the smallest group of classification commonly used; i.e., the group whose members have the greatest mutual resemblance. The common names of plants and animals often denote species. The scientific name of an organism, usually in Latin or Latinized words, consists of the genus name followed by the species name, as *Mammuthus primigenius*.

stratigraphic—referring to strata or layers as of rock or sediment.

tundra—a vegetation zone which surrounds the northern polar ice cap in North America, Europe, and Asia. Characteristic plants are mosses, grasses, lichens, and dwarf woody plants which are adapted to the low temperatures and short growing season of the area.

vertebra—one of the small bones which form the spinal column of vertebrate animals. The spinal column surrounds the spinal cord.

vertebrate—an animal with a skull and internal skeleton of cartilage and bone. A jointed vertebral or spinal column encloses the spinal cord. Vertebrates have a well-developed brain and are bilaterally symmetrical.

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